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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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THE JOURNAL
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THE ROYAL ASTRONOMICAL SOCIETY
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EXPERIMENTS WITH A FOUCAULT PENDULUM

By Stephen Stoot

IN the November 1931 issue of *L'Astronomie* there appeared a description of a Foucault Pendulum designed by M. F. Charron, Doctor of Science and Physics, Angers, France. This instrument runs electrically, and has a very simple device to prevent the pendulum from deviating from a straight swing soon after starting. This mysterious and troublesome peculiarity has prevailed in all the pendulum experiments from the time of Foucault down, and M. Charron goes to some length in describing the reasons why his simple device prevents this "ovalisation de là trajectoire" as he terms it. Being more interested in the practical results than in the Doctor's mathematics, I decided to construct a similar instrument, and after succeeding in so doing found that the little device he describes does all that he claims for it. My instrument is solidly fastened to a wall in my den, and is equipped with a protractor and vernier of my own design reading to 1°. It is operated by four dry cells, and I have let it run for three days at a stretch. My readings on the protractor have proved to be within a very few degrees of the calculated time for a complete apparent turn of the pendulum for the latitude of St. Hyacinthe, which should be one rotation in 33 h. 29 m. Having succeeded with this first instrument, it occurred to me to try M. Charron's device on an ordinary pendulum, and to secure if possible a permanent tracing of the paths it would describe.

During one of my visits to Toronto Dr. Chant showed me an illustration of a record made by Father Pigot in Sydney, Australia*, and although I could not hope to construct such an elaborate recording device as Father Pigot employed, I determined to try the experiment, and my results led to the writing of this article which I trust will be of interest especially to amateur astronomers who will be able to construct a similar simple device to the one I will now attempt to describe.

My experimental arrangement can, I believe, be followed from the isometric drawing, Fig. 1. The bob is made from a tobacco tin 3 in. in diam. and 3 in. high. A hole was bored in the centre of the

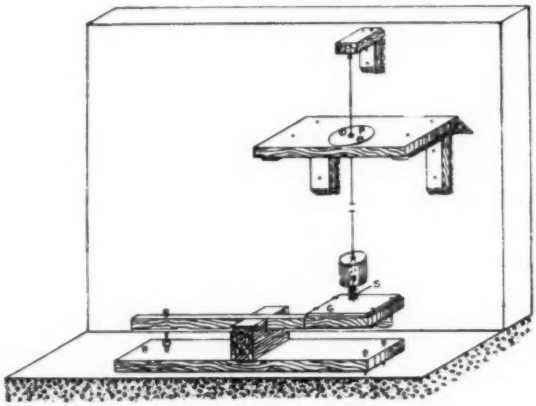

Fig. 1. Foucault Pendulum Arrangement.

bottom, and also in the centre of the cover to take a length of half-inch hardwood dowel. The tin box was then poured full of molten lead, and the cover placed on (with the dowel sticking through) before the lead had begun to set. Later when cool, the ends of the dowel were cut off flush with the top and bottom of the box. Its weight is 5½ lbs. A brass screw is inserted in the dowel at the top, and in the centre of the screw head a tiny vertical hole is

*In a paper by Father J. G. Hagen entitled "The free-pendulum experiment photographed," in Popular Astronomy, Vol. 38, p. 381, 1930.

drilled to the depth of ⅜ inch. One end of the suspension wire is inserted in this hole, and well soldered. The wire is No. 26 gauge, phosphor bronze. A larger brass screw is bored in the same manner for the actual suspension at the top, and the other end of the wire soldered into it, and this screw is run into a good solid bracket, the bracket being firmly fastened to the wall of my basement. The length from the suspension screw to the centre of the bob is 6 ft. 3 in. The little device at the bottom of the bob for tracing the paths on the smoked glass *G* is simply a piece of thin brass bent as shown, and has two holes bored in the right angled bends to take an ordinary blued-steel pin which slides up and down to take care of the arc which the bob makes in its swings. A small threaded wire is soldered on the back, and bent as indicated by the dotted lines, and screwed into the end of the hard-wood dowel. Allowing the bob to turn slowly, the threaded wire is bent a little one way and the other with a pliers until the point of the pin does not describe even the tiniest circle, and when this adjustment is finished the point is plumb. The lever (and platform) to raise the glass up to the pin explains itself. The base rests on the points of three screws on the cement floor, and another adjusting screw in the handle of the lever limits the motion of the platform which carries the smoked glass. The whole base and lever is carefully levelled in the position shown (before the glass is smoked) so that the tracing pin will touch the glass everywhere as the pendulum swings. Between readings the platform and glass fall down from the position shown.

The device of Dr. Charron consists of what he terms a small ring placed a little below the actual point of suspension so that the pendulum wire touches the inside of the ring at each stroke.

I used a phosphor-bronze plate *P* in which I bored a hole a bare ¼ in. in diameter for the wire to pass through. The plate was screwed to a shelf as shown, the holes for the screws being considerably larger than the screws, to allow the plate to be adjusted so that the wire passed through centrally. Two washers under the screw heads enabled me to tighten the plate in position. This is an important adjustment, and the wire must be as near dead centre of

the hole as possible to allow the pendulum to run evenly. The result of the experiment shows that the small ring of Dr. Charron does all that he claims for it. As long as the wire touches the ring the bob travels in a straight line, but when the pendulum swings become shorter, and the wire no longer touches the ring, then the ellipse begins as my tracings show.

Each of the tracings *a* and *b* in Fig. 2, was obtained with a six hours' run, with recordings taken at half-hour intervals. For tracing *c* the duration was seven hours, the length of the pendulum was 9 feet and the weight of the bob was 10½ pounds. From 0 to line 6 the intervals were 5 minutes, from 6 to 8 they were 15 minutes, from 8 to the second ellipse they were 30 minutes, while between the last two ellipses the interval was 60 minutes.

Tracing *a* Fig. 2 was made on the afternoon of March 12 from 2.45 p.m. to 8.45 p.m., and has something of interest recorded (at 5.45) which puzzles me. My pendulum started to *wobble* on itself, thereby making the pin or style to trace a wavy line. I tried to account for it by a train passing, a heavy truck, people moving upstairs, or a high wind shaking the house, but none of these can be taken as the cause. The afternoon was clear and frosty with hardly a breath of wind. Trains passed about five hundred yards away during the six hour run, trucks passed the house, and people moved upstairs, but these same conditions prevailed during the production of the other record, but not a sign of a wavy line appears on it. Draughts in my basement may be discounted because the pendulum bob was screened during the recording. My basement, moreover, is solid cement, floor, sides and ceiling. In view therefore of the account of a similar form of microseismoscope given on page 44 of the January 1932 number of *L'Astronomie*, I am wondering if my pendulum recorded a minor disturbance in our vicinity. The wobbling damped itself out before the next reading, as may be noted on the tracing.

A word or two regarding the operation of starting the pendulum and making the records may be useful to readers who wish to try a similar experiment for themselves. It is not necessary to start the pendulum by drawing it back with a string and burning it with a

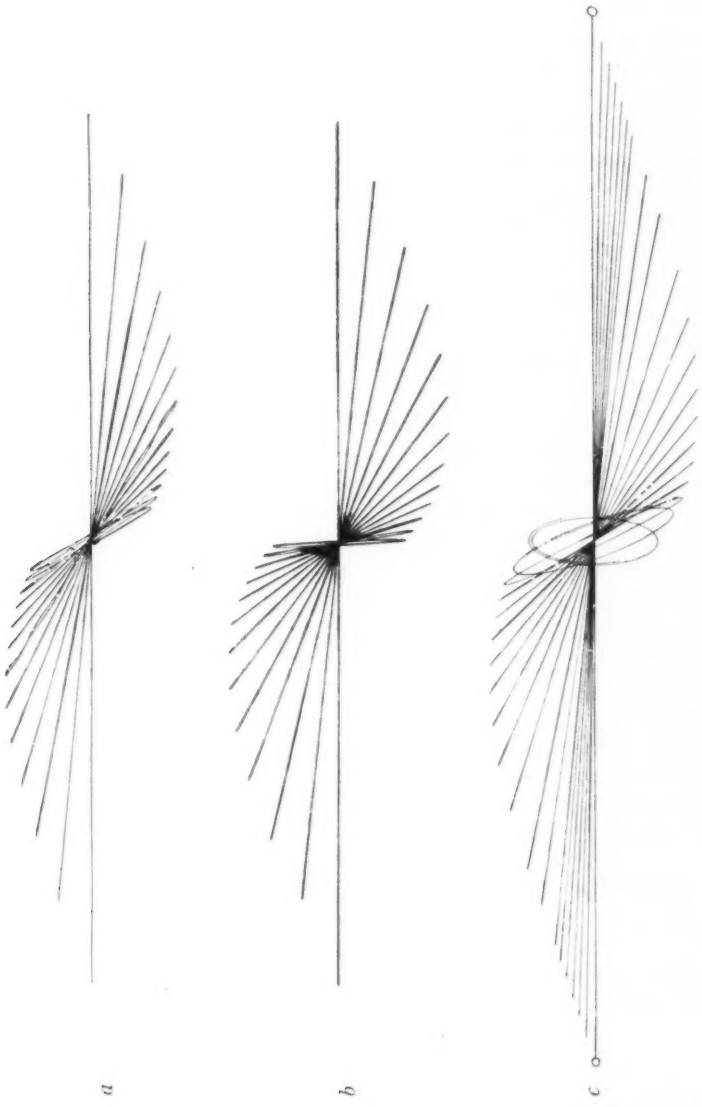

Fig. 2. Tracings with the Foucault Pendulum.

lighted match in the usual way. A few gentle pushes on the wire until the desired amplitude of swing is attained are only necessary, because even if at the start the pendulum swings in an ellipse, it will be found that at the end of about six or eight swings the bob will be moving in a plane, and will continue to do so until the wire ceases to touch the inner edge of the little ring.

In raising the platform of the recording device care must be taken to have the needle touch the smoked glass as near as possible to the centre of the pendulum swing, and to drop it again just as it reaches the centre after the complete line is traced. If the smoked glass be raised towards the end of a swing, a little loop or tail will appear on the traced line. This is due to the fact that the platform is describing an arc in coming up to dead level. Since the first experiment was made I have constructed an improved form of recording device which raises the glass horizontally all the way, and the precaution to avoid tails and curls is now no longer necessary with this improvement.

In conclusion I would strongly urge all readers who are mechanically inclined to construct either an electric pendulum as described by Dr. Charron in the French journal already named, or a more simple one such as I have described in the foregoing. Even if they do not care to trouble themselves in the matter of recording, the sight of the pendulum running at a right angle from the path on which it was started after a few hours is a very impressive one indeed. The experiment of Foucault is very well known and generally understood, but to have a pendulum actually mounted and running in one's cellar, or in one's den where one can reproduce this beautiful experiment at a moment's notice, is still better than just understanding it in a general way.

St. Hyacinthe, P.Q.

ECLIPSE OF AUG. 31, 1932; REVISED CALCULATIONS

By C. A. Chant

PROFESSOR JAMES ROBERTSON, director of the American Nautical Almanac, has just issued corrections to the original calculations for this eclipse. From 399 of the latest observations of occultations, furnished by observatories in various countries, including some made as late as April 20, 1932, there has been deduced a correction of +5".3 to the mean longtitude of the moon taken from Brown's table, and —0".8 to the latitude. Corrections to the ephemeris positions of the sun, derived from 164 observations made with the 6-inch meridian circle of the U. S. Naval Observatory during 1931, give +1".5 to the sun's mean longtitude and +0".07 to its latitude. The small latitude correction was neglected.

Utilizing these corrections, new elements of the eclipse were calculated. They result in a shift of the path of totality westward of approximately 0.7 mile.

For Montreal (McGill University) the local circumstances should now be:

Eclipse begins	Aug. 31,	19h.	14m.	11.55,	G. C. T.
Total eclipse begins		20	24	16.9	
Total eclipse ends		20	24	51.1	
Eclipse ends		21	29	47.6	

The duration of the total phase at places at different distances from the central line is as follows:—0 mi., 1 m. 41 s; 10 mi., 1 m. 39 s.; 20 mi., 1 m. 32.9 s.; 30 mi., 1 m. 21.7 s.; 40 mi., 1 m. 2.7 s.; 47 mi., 39.2 s.; 50 mi., 19.9 s. These numbers are for places near the St. Lawrence river, but hold approximately for other places in Quebec. The precise limits of the path of totality are also given in the same publication. Write U. S. Naval Observatory, Washington.

ECLIPSE OF THE SUN, AUGUST 31, 1932

By James Weir

IN the American Ephemeris the circumstances of the eclipse for various places are given. The following tables give similar information for places in Canada.

TABLE I

LOCAL CIRCUMSTANCES OF THE ECLIPSE OF THE SUN, AUGUST 31, 1932

Place	Lat.	Long.	Beginning			Middle		Ending		
			G.C.T.	Angle from North Point	Angle from Vertex	G.C.T.	Magnitude	G.C.T.	Angle from North Point	Angle from Vertex
	° ′	° ′	h. m.	°	°	h. m.		h. m.	°	°
Victoria, B.C.	48 31	123 25	18 22.8	345.0	10.4	19 24.3	0.39	20 26.1	90.2	87.0
Vancouver, B.C.	49 17	123 07	18 21.5	343.3	8.1	19 23.9	0.41	20 26.6	91.5	88.0
New Westminster, B.C.	49 13	122 55	18 21.8	343.3	8.0	19 24.2	0.41	20 27.0	91.6	87.8
Edmonton, Alta.	53 33	113 30	18 21.9	329.9	344.5	19 31.6	0.61	20 40.3	104.2	90.7
Regina, Sask.	50 27	104 36	18 34.3	328.0	333.8	19 46.5	0.67	20 56.4	108.5	83.6
Winnipeg, Man.	49 53	97 08	18 42.3	322.9	319.6	19 55.7	0.76	21 05.9	113.4	82.3
Port Arthur, Ont.	48 26	89 13	18 52.8	318.0	304.1	20 06.3	0.85	21 15.6	117.6	80.7
Toronto, Ont.	43 40	79 24	19 11.9	314.0	283.4	20 24.1	0.92	21 31.0	120.6	74.9
Ottawa, Ont.	45 24	75 43	19 12.3	309.7	278.2	20 23.4	0.98	21 29.3	123.2	79.8
Montreal, Que.	45 30	73 35	19 14.2	308.0	274.9	20 24.6	1.02 (Total Ecl)	21 29.8	124.1	79.6
Quebec, Que.	46 48	71 13	19 14.0	305.5	272.4	20 23.5	0.99	21 28.0	125.6	82.2
Fredericton, N.B.	45 57	66 38	19 19.9	302.8	265.7	20 27.7	0.95	21 30.6	126.9	82.1
Charlottetown, P.E.I.	46 12	63 08	19 22.4	300.4	261.9	20 28.9	0.92	21 30.5	128.0	83.4
Halifax, N.S.	44 40	63 35	19 24.9	301.5	261.2	20 31.7	0.94	21 33.4	127.2	81.0

TABLE II

LOCAL CIRCUMSTANCES OF THE ECLIPSE OF THE SUN, AUGUST 31, 1932

Place	Lat. Long.	Beginning (contact I)			Total Phase Contact II			Contact III			Ending (contact IV)		
		G.C.T.	Angle from North Point	Angle from Vertex	G.C.T.	Angle from North Point	Angle from Vertex	G.C.T.	Angle from North Point	Angle from Vertex	G.C.T.	Angle from North Point	Angle from Vertex
	° ′ ″	h. m. s.	° ′	° ′	h. m. s.	° ′	° ′	h. m. s.	° ′	° ′	h. m. s.	° ′	° ′
Lafontaine Park, Montreal	45 31 36 73 34 10	19 14 08	308 01	274 56	20 24 12	192 52	151 49	20 24 51	238 23	197 17	21 29 45	124 09	79 36
*Ditto, from Elements of Amer. Ephemeris		19 14 05	308 01	274 57	20 24 11	196 27	155 25	20 24 45	235 35	194 30	21 29 42	124 09	79 36
Parent, Que.	47 55 10 74 36 30 El. 1425′	19 08 40	307 12	278 02	20 18 16	132 15	94 38	20 19 59	299 33	261 47	21 24 45	124 45	83 03
*Ditto, from Elements of Amer. Ephemeris		19 08 40	307 13	278 03	20 18 12	133 42	96 05	20 19 54	298 19	260 33	21 24 40	124 43	83 01
Sorel, Que.	46 02 46 73 06 26	19 13 38	307 19	274 36	20 22 58	136 03	95 32	20 24 38	295 43	255 04	21 28 54	124 34	80 32
*Ditto, from Elements of Amer. Ephemeris		19 13 33	307 19	274 36	20 22 54	137 08	96 37	20 24 34	294 41	254 02	21 28 50	124 34	80 32
Summit of Mt. Orford, Que.	45 18 44 72 14 32 El. 2860 ft.	19 15 51	307 08	272 47	20 24 58	124 27	82 42	20 26 38	307 24	265 32	21 29 38	124 36	79 40

*In the 1932 Handbook of the British Astron. Assoc. the advice is given concerning the Besselian elements of the Amer. Ephem. and of the B. N. Almanac, that more probable values of the "x" and "y" elements are had by subtracting 0.00051 from x and adding 0.00018 to y, the remaining elements standing unaltered. These amendments, due to a communication of Dr. E. W. Brown of the probable correction, +5″.5, to the Moon's mean longitude at time of eclipse and of +1″.80 in longitude and +0″.23 in latitude to the sun, have been adopted in computing the circumstances tabulated above, except for the three marked *, where the unrevised results appear for comparison. Table III also shows the effect of the revision on that portion of the Central Line in Quebec Province and south of the St. Lawrence River.

TABLE III

COMPUTED POSITION OF CENTRAL LINE OF ECLIPSE OF THE SUN, AUGUST 31, 1932
FOR QUEBEC PROVINCE SOUTH OF THE ST. LAWRENCE RIVER

G.C.T.	h. m. s. 20 23 00	20 23 30	20 24 00	20 24 30	20 25 00	20 25 30	20 26 00	20 26 30	20 27 00	Note: From the revised elements of B.A.A. 1932 Handbook
Latitude	46° 25′.1	46 13.3	46 01.4	45 49.5	45 37.6	45 25.7	45 13.8	45 02.0	44 50.2	
Longitude	73 12.5	73 02.2	72 51.9	72 41.7	72 31.5	72 21.1	72 10.7	72 00.1	71 49.3	
Diameter of Umbra in miles	53.45	53.40	53.35	53.30	53.24	53.18	53.12	53.05	52.99	
Apparent Altitude of Sun	31° 30′	31° 24′	31° 17′	31° 10′	31° 03′	30° 55′	30° 48′	30° 40′	30° 32′	
Azimuth of Sun	S. 66° 56′ W.	67 18	67 41	68 03	68 25	68 47	69 09	69 31	69° 53′	
Latitude	46 23.9	46 12.0	46 00.1	45 48.3	45 36.4	45 24.5	45 12.7	45 00.8	44 49.0	Note: By Interpolation from Amer. Ephemeris
Longitude	73 10.0	72 59.8	72 49.6	72 39.3	72 28.9	72 18.4	72 08.0	71 57.3	71 46.8	
Duration of Totality	sec 101.5	101.3	101.1	100.9	100.7	100.5	100.3	100.1	99.9	

McGill University,
Montreal, P.Q.,
June 2, 1932.

THE TOTAL SOLAR ECLIPSE OF AUGUST 31st, 1932: SUGGESTIONS TO AMATEUR OBSERVERS

By R. K. Young

IN the May-June number of this Journal appeared an article by Miss A. V. Douglas pointing out the unique opportunity that the coming eclipse affords the amateur to contribute observations which will help to solve some of the problems which present themselves at this time and at this time only. The present article gives more detailed instructions to the amateur in order that he may make his observations to the best advantage. It is assumed that any amateur going to view the eclipse will not be alone but that there will be several members in the party. By dividing the observations each can have time to watch the spectacle of the eclipse itself, which is very impressive, as well as to make the observations assigned to him.

The Site for Observations. The belt of totality is about one hundred miles wide and extends from Montreal on the west side to a point about 35 miles east of the city of Three Rivers. A map of the path in the province of Quebec appears in the December, 1930 number of the Journal. There is very little advantage in any one place over any other within this belt. It is not essential by any means that you observe the eclipse from the central line; in fact it would be preferable if the amateur would not choose the central line. It is desired to have the observations, especially those made by the amateur, extend completely across the belt. Several of the organized expeditions will be on the central line so that observations at these points will be sufficiently taken care of. As regards the local conditions, an elevation is to be preferred which commands a reasonable view of the country. Each observer should provide himself, or herself, with a piece of dark coloured glass, or smoked glass, or blackened photographic film or plate.

It is essential that observers in sending in their observations record as exactly as possible the position of their point of observation. This may be done by reference to some landmark such as a church,

crossroad, railway station, river, etc. A map marking some such features, with the observer's location indicated, should be sent in with the observations.

Observers near the Edge of the Shadow. Observers who are located near either the eastern or the western edge of the belt of totality should attempt to locate the dividing line between the total and the partial eclipse. Answers to the following questions would be of value.

1. With the advent of totality was there any time when the bright disk of the sun was completely hidden? If so, how many seconds elapsed after the disk was completely hidden before any part of it reappeared?

2. Did you see white streamers extending out beyond the edge of the moon's disk which you thought belonged to the corona of the sun?

3. During the few seconds when the disk of the sun remained covered by the moon, could you observe on the earth any objects—buildings, water or trees—which were definitely in the sunshine and others which were in the shade? If you are situated near the eastern edge of the belt of totality, this phenomenon should be observed in the east and if you are near the western edge of the belt, the phenomenon will be seen in the west. Make a sketch showing where the edge of the shadow seemed to pass.

Total Light at the Time of the Eclipse. A good way for the amateur to measure this is to determine the smallest size print which he can read at the time of eclipse. For this purpose a newspaper will serve very well. Afterwards he may standardize his results by determining in a darkened room at what distance from a standard candle he can read the same size print as could be read at the time of eclipse.

Observations of the Shadow Bands. Just prior to the arrival of totality and for a few seconds after totality, there is usually observed a series of shadows moving over the surface of the ground. The points to be observed in connection with these are:

1. At what time were they observed and how long were they visible?

2. Did the shadows take the form of waves moving in a definite direction or did they appear as dancing patches of light and shadow with no definite motion?

3. If the shadows appeared as waves, how fast did the waves seem to move and what was their direction of motion?

4. What was the distance between the shadows?

In order to obtain good observations of this interesting phenomenon it should be observed by several observers. Provide yourself with a watch which has a seconds hand, and prior to the eclipse see that the minute hand is set so that it agrees with the seconds hand, that is, when the seconds hand reads zero, the minute hands is coincident with one of the minute divisions. Spread on a level place on the ground a white sheet a few feet square—a bed sheet will serve very well. Orient the sheet so that one edge points in a known direction. This direction may be fixed by noting the time on the watch when the shadow of a plumb line falls along the edge of the sheet. See that the sheet is stretched sufficiently to remove undulations in its surface. These preparations should be made an hour or more before totality. Provide yourself also with a number of strips of wood four or five feet long.

When the shadows are first seen, note the time on your watch, and if there is any definite direction of motion place one or more of the strips of wood along the crests of the waves and one or more in the direction in which the shadows seem to move. Try to follow the waves across the sheet and estimate the time for a wave to move from one side to the other. When these observations have been made, transfer your attention to the sun and note carefully the reading on the watch when the corona first becomes visible.

The shadow bands may remain visible up to the time of totality or a short time thereafter, consequently one observer should not attempt all the observations. It is important that the watch time of the beginning of totality be noted as well as the time the shadows were first seen. It would be well for one observer to confine his attention to these two points only. After the eclipse the distance between the crests of the waves as well as the direction of motion can be determined from the strips which have been placed on the

sheet. It would be advisable also to have two sheets, one for the observations of the shadow bands as seen just before totality, and the second for those seen just after totality has ended.

Observation of the Temperature. It is well known that the temperature falls several degrees during the time of the eclipse and it would be very interesting and valuable to have a complete record of these changes at various points in the shadow path. Provide yourself with a good *mercury* thermometer and a watch. The thermometer should be suspended in the shade, *i.e.*, on the north side of a building or in a place where no direct rays of the sun can reach it. Beginning about 1.30 p.m. E.S.T., take readings at five minute intervals until 3.10 p.m. Then take readings at minute intervals for the next half hour, noting the minimum reading at the time of totality. Starting at 3.40 p.m. continue readings at five-minute intervals for another hour. Take time also to note the watch reading when you first see the corona. These observations will occupy all the attention of one observer.

Observation of the Barometer. The changes in temperature are probably accompanied by barometric changes but observations at former eclipses have shown that these variations are small, too small to be observed without very delicate instruments. Some of the organized expeditions from the observatories will include attempts to record these changes and I think the amateur will not likely be able to obtain any record of value in this connection.

Observation of the Wind. Changes in the barometer and temperature are accompanied by changes in the velocity and direction of the wind. There are two ways the amateur may make observations, with the aid of a wind vane or by observation of the the clouds. The observation with the wind vane will refer to the winds near the surface of the ground and the motions of the clouds will reveal the nature of the changes in the winds at higher levels.

It will be a comparatively simple matter for the amateur to construct a wind vane out of a thin board or shingle and to record during the progress of the eclipse any changes in the direction. Such changes have been observed at former eclipses. Observations of the clouds, both for direction of motion and velocity, can be

made with the aid of a little instrument called the nephoscope which can be constructed for a small outlay. For the details of its construction and the method of using it, the amateur is referred to Milham's "Meteorology," p. 226.

Observations of Clouds. Although these can be best observed with the nephoscope in the hands of a skilled observer, the instrument is difficult to handle and observations can be made without any instrument. The observer should note the amount of cloud covering the sky, estimating this in percentage 0-100; also the form of the clouds—stratus, cumulus, etc.—and whether the clouds are high or low and the direction in which they are moving. Observe whether they seem to increase or decrease as totality approaches.

Observation of Humidity. The humidity of the air, *i.e.*, the amount of moisture it contains, can best be determined from observations of the wet-bulb thermometer in conjunction with the readings of the temperature already explained. A thermometer is mounted on a wooden strip about fifteen inches long and the bulb is covered with a wrapping of cheese cloth which is kept wet. A handle is attached to the strip so that the thermometer can be whirled through the air. The evaporation of the water in the cloth surrounding the bulb causes a lowering of the temperature and from the difference in this reading and the ordinary temperature the humidity can be determined. The observations consist in obtaining the wet-bulb readings for the same times as for the dry-bulb already explained. (See Milham's "Meteorology," p. 200.)

General Instructions—Important. Observers should make all their records on ruled paper so that in the hurry of making the records at the time of the eclipse there will be no danger of confusing which readings belong to which times. It would be well to rule a form before the eclipse and enter in the first column the times when the readings are to be taken. Forms should be ruled separately for the temperature records, dry-bulb and wet-bulb, cloud observations and wind observations.

If observers will send in their observations to Dr. A. V. Douglas, McGill University, they may rely on their results being utilized to the best advantage.

ADDITION BY THE EDITOR

Observations of Birds and Animals. Dr. E. Zinner, director of the Remeis Observatory at Bamberg in Bavaria, Germany, sends the following note.

Occasionally at the time of an eclipse of the sun, birds have been observed to show all the signs of fear. Thus they would resemble those men who view an eclipse as something extraordinary and as a sign of divine anger. We should in this way be able to trace the beginning of astrology from the birds. Unfortunately our information is not of such a nature that any such conclusion can be drawn. The eclipse of August will afford an opportunity to increase our knowledge on this subject. It would be important to observe the following:—(1). The behaviour of domestic animals, such as dogs, cats and horses. (2). The behaviour of birds and wild animals. (3). Do these animals show excitement or fear before totality or first during totality? How did the excitement or fear show itself? Did this condition continue long or did it subside immediately after totality? Did the animals seek human protection, or did they creep away into the underbrush or into the house? Did some animals appear unaffected whilst others at the same time were excited?

THE EARTH AS A PLANET*

By C. A. Chant

LOOKING back over the long history of astronomy we recognize three great publications which stand out as landmarks on the road of intellectual progress. The first was written by Ptolemy, an able Greek mathematician of Alexandria, about 150 A.D. He called his work "the great composition." About 800 A.D. it was translated into Arabic at the order of Haroun Al Rashid, the hero of the "Arabian Nights," and through this translation it acquired the name "Almagest," or "the greatest." It is the only complete compendium of ancient astronomy which we have, all other works being but fragments of the originals. The "Almagest" is a marvel of ingenuity and research, and it remained the standard treatise on astronomy for fourteen centuries.

In the universe as prexented by Ptolemy the earth was the central body. It was heavy, at rest, immovable, and the sun, moon, planets and fixed stars all revolved about it. Thus the abode of man was the most important of all the bodies. One might almost expect this ancient writer to consider the earth to be flat; but no, his first postulate is that it is spherical in shape, and he gives some of our usual arguments (such as the disappearing ship) in support of his view. At the present time the sphericity of the earth is impresed upon us in a wonderful way by the radio,—when we hear Big Ben in London strike midnight while it is 7 p.m. in Toronto, or when a speaker in Tokio closes his address at 8.14 on Tuesday morning while our timepieces show 6.14 Monday evening.

Of course in Ptolemy's time there were persons who did not accept his theory, and as the centuries passed the number of such unbelievers increased. At last came Copernicus, mathematician, physician, and canon of the church. He was born in 1473, and after a lifetime of study and meditation he published his great book entitled "Concerning the Revolutions of the Heavenly

*Broadcast from Station CFRB on January 25, in the University of Toronto series of broadcasts.

Bodies." A copy of it was placed in his hands as he lay on his deathbed in 1543.

According to Copernicus the sun occupied the chief central position while the earth was reduced to the status of a planet revolving, with five others, about the central body. Their orbits were assumed to be circles and Copernicus was able to compute their relative sizes though not the absolute magnitude of any of them. He believed them to be much smaller than they actually are.

The theory of Copernicus demanded a complete overthrow of the ideas of the universe generally prevailing at the time, and, as in all such cases, it aroused strong opposition. Indeed it seems to me that in the domain of human thought astronomy has always led the way, and its influence for straight thinking has ever been paramount. But the Ptolemaic theory did not disappear at once—not until a hundred years had elapsed was it considered to be definitely overthrown.

It may be remarked that the demonstration that the earth was but one of a number of planets removed the main foundation of the ancient structure of astrology, and the influence of the astrologer began to wane, though in the last few years he, or rather she, has been having a slight revival—chiefly amongst those who care little whether the earth goes round the sun or the sun round the earth.

The Copernican theory is essentially the basis of the solar system as we know it to-day. Copernicus considered the planets to move in circular paths; seventy years after his death Kepler showed that the orbits actually were ellipses, but the ellipses could hardly be distinguished from circles. Copernicus advocated his theory on account of its greater simplicity; now we have many proofs of its correctness, obtained by means of the telescope and the spectroscope.

The third great book was Newton's "Principia," published in 1687. In it was the final demonstration of the Copernican theory. Up to this time investigations into the solar system dealt simply with circles and bodies of different sizes,—a mere matter of geometry. Newton breathed into the system the all-pervading principle of gravitation and it became a living thing. Copernicus and his

immediate successors showed clearly *how* the planets revolve about the sun: Newton showed why they move in their orbits.

As Newton's principle of universal gravitation perfectly accounted for the motions of the planets it was unanimously accepted. Astronomers then used the principle as an instrument to investigate all problems of motion in the solar system with some remarkable results. In 1781 the illustrious William Herschel discovered the planet Uranus, which was shown to revolve in an orbit far beyond that of Saturn—until then thought to be at the outer boundary of the solar system. Utilizing the law of gravitation, the precise path it should follow was computed; but during the early part of last century it was found that the planet was not exactly following the path. What was the matter? It was suspected that there was another planet still farther away which by its attraction was pulling Uranus slightly aside. From the very minute discrepancy between the predicted place and the observed place two mathematical astronomers were actually able to calculate in what direction the unseen body must be. A telescope was turned in the direction specified and the planet Neptune was discovered on September 23, 1846. Less than two years ago another planet was discovered in the same way. It is still farther from the sun and was found only after years spent in computing its position and then more years in searching for it. The name Pluto has been given to it.

Let us now glance at the solar system and especially the earth. The planets in order from the sun are, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. The first and the last are the smallest, while the middle ones, Jupiter and Saturn, are the largest. This arrangement of sizes probably arose from the way the planetary system was formed from a portion torn off the sun, but of this I cannot speak further.

As I have already stated, the path of the earth about the sun is an ellipse. I suppose you know how to draw an ellipse. You drive two pins in a board and over them put a loop of string. Placing a pencil in the loop you move it about, always keeping the string taut. The curve traced out is an ellipse and the points where the pins are, are the foci. The sun is at a focus, not at the centre of the curve

It is evident then, that as the earth moves round in its orbit its distance from the sun is continually changing. The earth was at perihelion, that is, at that point of its orbit nearest the sun, at 11 p.m. E.S.T., January 1, 1932. Its distance then was 91,343,700 miles. It will be at aphelion, or the point farthest from the sun, on July 3, at 3 p.m., at which time the distance will be 94,455,900 miles, which is 3,112,200 miles greater than the perihelion distance. Thus winter in the northern hemisphere occurs when the earth is nearest the sun. Our cold weather is due to the inclination of the sun's rays to the earth's surface. The earth's mean distance, which is one half of the longer axis of the ellipse, is approximately 92,900,000 miles. To-day, January 25, at noon E.S.T., the distance was 91,456,700 miles; tomorrow at the same hour it will be 91,467,600 miles. Thus in 24 hours the distance will increase 10,900 miles, which is at the rate of 7½ miles per minute. At the end of my address this evening the earth will be about one hundred miles farther from the sun than when I began.

The speed of the earth in its orbit is not uniform, but averages 18½ miles per second. The rule for finding the speed at any moment constitutes the second of Kepler's famous laws of motion. Consider the line joining the centre of the sun to the centre of the earth. The earth moves in such a way that this line sweeps over equal areas in equal times. I have calculated that during every second it sweeps over 859,000,000 square miles, which is 230 times the area of all Canada.

Perhaps I should remark that actually the centre of the earth does not describe a perfectly smooth ellipse. The revolution of the moon about the earth gives it a slight motion in and out every month. Then the other planets exert their attractions on it and it is sometimes held back, sometimes helped forward. The mathematical astronomer takes into account all these little "perturbations," as they are called, not only in the earth's motion but also in the motion of every planet.

In conclusion let us briefly discuss the ultimate destiny of the earth. After the principle of universal gravitation had been established the following problem was presented to the astronomer: given the various bodies of the solar system revolving about the sun in their present orbits, what will happen to them in future ages?

Two eminent French mathematicians, Lagrange and Laplace, after years of labour presented their solutions, which agreed that the system was so adjusted that the mutual attractions of its members would never lead to the destruction of any of them, in other words, the solar system would retain its permanence with no material change through the unending lapse of ages. However the problem was attacked again in our own generation by Poincaré, an equally distinguished French mathematical astronomer, and he showed that his great predecessors had neglected certain considerations which in reality rendered their conclusions invalid, and the stability of the system was not assured. Indeed the approach of some other of the suns of space might entirely disrupt our system, and it is even possible that a comet in its course about the sun might collide with the earth with catastrophic results which we can hardly imagine. However such events are only remotely possible and need not cause alarm. Of course if the sun's store of radiant energy, obtained from annihilation of its material, should be exhausted the earth would become a frozen mass and, the sun's material and therefore attraction being gone, it might wander off into space; but such a contingency cannot arise in a million million years and residents of the earth need not be perturbed at the prospect.

VELOCITY STANDARDS IN O AND B TYPE SPECTRA

By J. A. Pearce

THE problem of wave-lengths for the spectral lines in classes F to M is complicated, owing to the unavoidable blending of the lines. Few, if any, are purely monochromatic, and the resulting blended wave-lengths not only vary from type to type but depend upon the dispersion and spectrograph employed. Any series of wave-lengths would hence be only applicable to a definite spectral type, for a particular dispersion used at a specific institution.

In class A, however, the problem of blending is not quite so acute, the blended lines decreasing progressively as we proceed from F0 to A0. In many cases, the intensities and the laboratory wave-lengths of the principal contributors to the lines are so well known that a blended wave-length, sufficiently accurate for the determination of radial velocities, can be adopted.

In classes B and O, with very few exceptions, all the lines are monochromatic, and it is only a question of accepting the most accurate laboratory determinations of the lines concerned. During the past ten years the radial velocities of the O and B type stars have been based upon laboratory, rather than stellar,wave-lengths. As the spectral analysis of the enhanced elements, present in the spectra of these classes, proceeded, the values have been revised from time to time. Our knowledge of the several stages of ionization of oxygen, nitrogen, carbon and silicon, the principal elements concerned, is now so complete, that it is possible to adopt values of the wave-lengths which will stand without sensible revision for a considerable period.

At the 1928 meeting of the I.A.U. Commission No. 30, on stellar radial velocities, proposed the preparation of a table of wave-lengths of the lines appearing in the spectra of O, B and A stars, which would be suitable for the accurate determination of radial velocities. The following table of the lines in O and B type spectra is suggested in accordance with this proposal. The table is limited to the region λλ3900-5000, corresponding to the usual single prism dispersion spectra.

VELOCITY STANDARDS IN O AND B TYPE SPECTRA

I. Primary Standards

Wave-length	Atom	Authority	Wave-length	Atom	Authority
4921.929	He II	2	4267.16	C II	7
4861.327	H	1	4143.759	He I	2
4713.143	He I	2	4130.884	Si II	4
4685.74	He II	3	4128.053	Si II	4
4596.178	O II	5, 6	4120.812	He I	2
4590.974	O II	5, 6	4119.221	O II	5, 6
4574.777	Si III	4	4116.104	Si IV	4
4567.872	Si III	4	4103.394	N III	5, 6
4552.654	Si III	4	4101.738	H	1
4541.61	He II	3	4097.330	N III	5, 6
4481.228	Mg II	9	4088.863	Si IV	4
4471.477	He I	2	4075.868	O II	5, 6
4437.549	He I	2	4072.162	O II	5, 6
4416.975	O II	5, 6	4069.794	O II	5, 6
4414.904	O II	5, 6	4026.189	He I	2
4387.928	He I	2	3994.996	N II	5, 6
4349.428	O II	5, 6	3970.075	H	1
4340.466	H	1	3968.465	Ca II	8
4319.635	O II	5, 6	3964.727	He I	2
4317.144	O II	5, 6	3933.664	Ca II	8

II. Secondary Standards

Wave-length	Atom	Authority	Wave-length	Atom	Authority
4651.46	C III	10	4379.100	N III	5, 6
4650.844	O II	5, 6	4351.270	O II	5, 6
4649.141	O II	5, 6	4168.97	He I	12
4641.873	N III	5, 6	4153.304	O II	5, 6
4640.632	N III	5, 6	4009.27	He I	12
4638.857	O II	5, 6			
4634.145	N III	5, 6			
4523.59	N III	11			
4514.861	N III	5, 6			
4510.906	N III	5, 6			

Notes on the Wave-lengths

1. Hydrogen: The Work of W. E. Curtis,[1] is still the accepted authority for this element.

2. Helium I: The most accurate determination of the principal lines of helium is that of P. W. Merrill.[2] Of the 11 lines of He I in the table, 7 belong to the singlet system, and 4 to the doublet system, viz.: λλ4713, 4471, 4121, 4026. Merrill's measurements refer to the brighter and violet components of the doublet series. The separations of the components vary from 0.22A for λ4713 to 0.17A for λ4026, and their intensities as given by Runge and Paschen[13] are (<1, 3), (<1, 6), (<1, 3) and (<1, 5) respectively. The separate components have not been observed in stellar spectra and hitherto all investigators have disregarded the weak redward components, basing their radial velocity determinations upon the stronger components solely. Considering the faintness of the redward components it does not seem advisable to adopt blended wave-lengths as standards for these lines.

3. Helium II: The measures are due to Paschen.[3] The faint companions to the violet of the Balmer series, while observable in certain O type spectra are not recommended as standards. It is well to point out in this connection that in the earlier O type spectra, the hydrogen lines must be measured with caution, as blends with the Pickering companions will cause the line to be measured too far to the violet, thus introducing errors in the velocities.

The Pickering line λ4199.87 He II is frequently blended with λ4200.06 N III and should be avoided.

4. Silicon: Fowler's[4] analysis of the successive stages of ionization of silicon provide accurate wave-lengths for the lines of Si II, Si III, and Si IV, occurring in these stars.

5. Oxygen: The most recent measures of the Oxygen II spectrum are due to C. S. Beals.[5] His determinations are regarded as having a higher weight than the former measures of J. S. Clark,[6] inasmuch as Beals used much more extensive material, and duplicated his observations at another institution, using different spectrograph, different measuring instruments and different methods of plate reduction. Clark's values of the wave-lengths

are conveniently shown in parallel with Beals' in the latter's paper. A systematic difference in their wave-lengths exists. For the 11, O II lines of the Primary standards Be−Cl = −0.003A; and for the 5, O II Secondary standards Be−Cl = −0.008A. The adopted values have been derived by assigning relative weights of 3 to 1 in favour of Beals. None of the adopted wave-lengths differ from Beals' values by more than 0.005A, and the average difference is +0.0013A.

The adopted wave-lengths for λ4069.794 is a blend of the two components of the line.

Beals		Clark
4069.636	(4)	4069.635
4069.897	(6)	4069.903
4069.793		4069.796

6. NITROGEN: The N II and N III spectra have also been recently measured by Beals.[5] Previous measures were due to Clark,[5] Fowler,[11] and Fowler and Freeman.[14] A similar systematic difference between Beals and Clark exists for Nitrogen. For the 9 lines in the table, Be−Cl = −0.010A. The adopted values were computed by assigning the same relative weights.

7. CARBON: The single line of C II, in the table, λ4267.16 is a blend of 4267.27 (10) and 4267.02 (8). The wave-lengths are due to Fowler and Selwyn.[7] The spectrum of C III has been measured by Bowen.[10] Of the 3 lines in this region, viz.: 4648.70 (3), 4651.46 (2) and 4652.65 (1), only the central line is suggested as suitable and this is frequently blended with the O II line λ4650.844.

8. CALCIUM: The work of H. Crew and G. V. McCauley[8] was adopted.

9. MAGNESIUM: The laboratory values of Fowler[9] are 4481.327 (1) and 4481.129 (2) with a weighted mean of 4481.195. A stellar value of 4481.230, due to Adams,[15] has hitherto been used.[16] W. E. Harper[17] from 361 measures of 400 A type stars finds the value to be 4481.310. Dunham[18] measured 4481.25 in α Persei. He gives the relative intensities of the Mg II components as equal (100). The Ti line 4481.26 (30) is certainly a contribution to the line in

the A and F type stars. Adopting equal intensities for the Mg II components, an O and B type value of 4481.228 is suggested.

Dominion Astrophysical Observatory,
Victoria, B.C.
March 30, 1932.

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WAVE LENGTHS IN A TYPE STARS

By W. E. Harper

THE determination of the velocity of a star towards us or away from us is based upon the shift of the stellar lines from their normal positions in the spectrum. If the star is approaching, its light waves are in effect shorter than normal and the resulting spectral lines are shifted to the violet by an amount proportional to the velocity of the star towards us. If the star is receding the shift is to the redward end of the spectrum.

To measure these shifts it becomes necessary to have a suitable comparison spectrum impressed on the plate on either side of the star spectrum. The particular one used at Victoria is the iron arc which gives numerous lines throughout the length of the spectrum suitable for standards from which we can measure the shifts of the stellar lines. If a star at rest with respect to ourselves should happen to have an atmosphere in which iron vapour is present then a set of lines will be found in its spectrum coincident in position with the iron-comparison lines, that is, they will join on to and make one continuous line with the broken ends of the comparison lines. If, however, the star should be approaching or receding there will not be this continuity but a displacement of the stellar with respect to the comparison lines.

All the lines, however, should show the same shift when expressed in terms of velocity. And this is true not only for the lines of the element which happens to match the comparison used but for all the lines due to any element whatsoever in the star's atmosphere. This presupposes that we know the normal wavelength of every line occurring in the spectrum if we are to use it in determining the velocity from the line shift. In the case of the hotter stars, technically known as the O and B types, which have simple spectra with relatively few lines due to hydrogen, helium, oxygen, nitrogen, silicon and a few other elements there is not much uncertainty. We can adopt the laboratory wavelengths for these lines with a reasonable degree of assurance as they are in general isolated in the spectrum. In the case of solar

and later type stars (G-K-M), where the lines are numerous and closely crowded together, blending is bound to occur and trouble arises in arriving at the normal wave-lengths of these composite lines. The practice very often is to match spectra of this type directly against a similar one whose velocity is known and in this way a knowledge of the normal blended wave-length is unnecessary.

In between these two groups lie the A-F stars in which there is an increasing number of spectral lines as we proceed from A to F. It is with the spectral lines in the A type (the hydrogen stars so-called because in them hydrogen reaches its maximum intensity) that this article particularly deals although the results obtained are in large measure applicable to the F-stars, at least those in the earlier subdivisions.

The A type stars are characterized by the strong Balmer series of hydrogen. In some stars these are the only lines found. The ionized lines of calcium, H and K, are usually present, the former being in general blended with $H\epsilon$ of Hydrogen. The increasing strength of K as we proceed from A to F is a partial basis of classification on the Harvard system. In other stars again in addition to the foregoing lines we have an increasing number of metallic lines, mostly of iron and titanium and many of these are due to the ionized atoms. Both the arc and enhanced lines of other elements are also present, such as the well known enhanced line of magnesium $\lambda 4481$.

In the simplest spectra of this type where only a few lines occur laboratory values suffice. Where the spectra become rich in lines with consequent blending it is desirable to have some knowledge of the components entering into a blend and their relative intensities. The practice in early days was to use Rowland's Table of Solar Wave-Lengths as a guide and to compute a blended value based upon the intensities as given in that work. Only the lines due to elements suspected to be present in the star were so incorporated. In course of time certain of these complex lines were seen to give results systematically different from the mean of that for the plate in general. Such systematic differences could be used to deduce a normal value for the wave-length concerned more in keeping with the observed trend of the residuals. Such empirical values of the blended wave-lengths were determined

by the writer at Ottawa in the case of the star 14 Aurigae and some of these values were adopted by R. K. Young, who compiled the list of wave-lengths first used in the Victoria radial velocity work. For the remainder of the list Young used the best determined laboratory values at that time.

This table has been used throughout by the writer not only in the original radial velocity programme where the director and the other three members of the staff co-operated but since then in an extended programme of A type stars. It was early noted that a few wave-lengths might be improved but the values have been used consistently throughout. As these were on the Rowland System they were transferred to the International System a couple of years ago in conformity with the recommendations of the Union. In the case of the stellar lines the wave-lengths were adjusted by the corrections given in Revised Rowland, page VII.

The same procedure might logically have been followed in the case of the comparison lines. However, there was in existence at the Observatory at that time a table of comparison wave-lengths which were based largely on Burns, as his determinations were seemingly the most reliable when the table had been prepared some years previously for the B-type stars. It was noted that the wave-lengths of the iron arc as recommended by the Union were slightly different to these and systematically so, the difference in the sense Victoria (Burns) minus I.A.U. for 23 comparison lines most frequently used being +.0034 angstroms. Two lines are given as a sample of the differences concerned. The first column shows the wave-length as adopted in the tables first used at this observatory. The second column shows the corrections necessary according to Revised Rowland to reduce to the International System. The third column shows this revised value while the other two columns give Burns' determination (as then in use here) and the value recommended by the Union.

Original	Correction	Revised	Burns	I.A.U.
4325.932	−.158	.774	.770	.765
4337.214	−.160	.054	.052	.049

If the I.A.U. values had been adopted instead of those in the table referred to (Burns) it would have meant that future measures would be more positive to the extent of 0.2 km. per sec. On the

other hand if revised values had been adopted for the comparison lines by applying similar corrections to them as to the stellar lines then velocities 0.3 km. per sec. more negative on the average would have resulted. Probably the best course to have pursued at that time of change would have been to have adopted the wave-lengths recommended by the I.A.U. for the iron arc comparison lines and applied a systematic correction of +0.5 km. to the velocities of the earlier plates. In talking over the matter, however, with the director it seemed best for the sake of uniformity within the Observatory to adopt the comparison wave-lengths as then in use, since they were about midway between the two others, in which case only a small systematic difference would exist between the two systems. Thus, to sum up this phase of the question, stellar wave-lengths were transferred to the International System by the corrections given in Revised Rowland but Burns' determinations on the International scale were used for the comparison lines.

Although the winter section of the A-programme is, owing to wretchedly poor weather during the past two or three winter seasons, not yet wholly completed its approaching completion has led to some provisional investigations of the results. Many of the brighter stars were purposely included so that we might have their spectra and while radial velocity results for these had previously been obtained at other observatories nevertheless it was deemed worth while to measure those plates secured at Victoria. An intercomparison of the results for all A type stars in common with other observatories showed that the writer was consistently negative with the best determined values at other places to the extent of about 1 km. per sec. In a paper presented to the Royal Society of Canada last year various possible causes were studied and it was concluded that the curvature correction used at Victoria of −1.00 km. per sec. would account for 0.3 km. of the difference as a better determination of that constant for the region of spectrum used is −0.70 km. per sec.

The question of the wave-lengths of the stellar lines used was left open for further study. It seemed worth while to study anew the residuals given by each line from the mean of the plate. It is generally recognized that slight differences of wave-length will

be found for certain lines as we proceed from one type to another. The assumption, moreover, that stellar wave-lengths are the same as those for the corresponding elements in the laboratory cannot be accepted without question. Jewell, in 1896, found a slight difference between arc and solar wave-lengths and this has been further studied by St. John and Adams at Mount Wilson and their conclusion that the solar wave-lengths are roughly .007 angstroms to the red with respect to the corresponding arc lines is accepted. Moreover minor differences have been found in the resulting velocities depending upon whether the arc or enhanced lines of the elements are used.

It was felt that while these minor differences would persist, yet a working value of the wave-lengths concerned would be obtained by studying a number of spectra of all types from A0 to F0. Accordingly 200 were selected in which no fewer than 10 lines on each had been measured. While a lower average deviation, taken without regard to sign, would doubtless have been secured had spectra been chosen with sharp lines only, yet a better cross-section of the type is secured by choosing spectra having lines of diffuse as well as of sharp character.

The plates used had all been secured with single prism dispersion with the camera of medium focal length (IM). As the prism has been refigured once and the system changed from Rowland to International, three different tables have been used in the reductions and care has been necessary so as not to confuse one line with another. The residuals of each line from the mean were taken and averaged both without regard to sign and with regard to sign. The results showed some lines with considerable systematic residuals and it was felt that before accepting such as definite more of the data at hand should be drawn upon. Consequently 200 additional spectra of similar type and character to the first batch were selected and the residuals tabulated in the same way. Almost identical results were secured in the two cases so that while much more material could have been used it was not deemed necessary to do so. The combined results are given in two tables, the first one being the Main List, the second a Supplementary List of wave-lengths. Column 1 gives the wave-lengths on the International System as heretofore used; column 2 the

number of times the line was measured on the 400 plates selected; column 3 gives the numerical value of the residual, *i.e.*, taken without regard to sign; column 4 gives the algebraic residual; column 5 the correction necessary to the wave-length to make this residual vanish; column 6 gives the revision of λ suggested while the last column deals very briefly with identifications of the elements concerned in the line.

Some of the values of the wave-lengths in column 6 are starred as indicating that so much uncertainty exists in the blends that it seemed better to accept the empirical value which satisfied the line residuals. The elements given in the last column are not necessarily all that occur but are deemed the principal ones. The presence of other elements in A type spectra has been conclusively established by different investigators but the intensities of such are generally weak and the effective wave-lengths would not be materially changed, it is thought, by their inclusion. Nevertheless, by reason of this very uncertainty some might prefer to accept the definite corrections (column 5) which the residuals call for. The wave-lengths recommended in almost every case tend to improve matters and in most cases are nearly in agreement with what the residuals call for. They are formed from the components indicated in the last column in which the intensities shown have been based upon results from the laboratory, from the sun as indicated in Revised Rowland, from Dunham's high dispersion spectra of α Persei, from Albrecht's study of three-prism spectra of γ Geminorum and to a lesser degree from three-prism plates of our own. Additional studies of high dispersion spectra of typical stars will further increase our knowledge of these blends and will be a worthwhile contribution to the subject.

WAVE-LENGTHS FOR CLASS A STARS

Main List

λ	*n*	|Δ|	Δ		λ Recommended	Identification and Remarks
			km	λ		
3933.667	160	8.1	+2.10	−.026	3.664	Ca+
4005.263	135	8.9	−5.25	+.070	5.333*	Fe .246 blended with others
4030.695	45	7.4	+5.12	−.069	0.610	Fe .504 (3), Ti .514 (6), Mn .760 (6)
4045.790	327	8.4	+3.42	−.046	5.739	Fe .132 (1), Fe .815 (8)
4063.567	266	8.8	+4.19	−.057	3.539	Fe .292 (2), Fe .601 (8)
4071.739	164	9.4	+3.84	−.052	1.687*	Fe .743 probably violet component
4077.721	233	11.0	+7.36	−.100	7.644	La+ .35 (1), Y .38 (1), Sr+ .714 (8)
4101.740	197	8.8	−0.77	+.011	1.738	Hδ
4118.678	58	8.6	+0.94	−.013	8.650	Fe .549 (5), Fe .901 (2)
4128.059	39	8.7	−4.69	+.065	8.053	Si+ .053 though possibly V .101 and others
4130.892	27	7.6	−1.57	+.022	0.884	Si+ .884
4143.686	224	10.8	+1.54	−.021	0.682	Fe .417 (5), Fe .871 (7)
4198.511	210	10.7	−6.23	+.087	8.605	Fe .239 (4), .331 (4), .632 (3), 9.100 (5)
4202.024	74	8.2	−3.63	+.051	2.031	Fe .031 main, probably blended with Fe .752
4215.578	254	8.5	−3.51	+.049	5.636	Fe .416 (2), Sr+ .515 (10), Fe 6.186 (3)
4226.953	245	10.0	+3.02	−.042	6.911	Fe .426, Ca .735, Fe 7.435 blended
4233.270	290	8.1	−1.75	+.024	3.275	Fe 2.729 (2), Fe+ 3.164 (8), Fe 3.606 (6)
4235.846	40	8.2	−3.95	+.056	5.902*	Fe .950 main, probably blended with Y+ .70
4250.464	124	8.2	−4.02	+.057	0.481	Fe .131 (7), Fe .788 (8)
4260.405	87	7.3	−2.67	+.038	0.425	Fe 9.985 (1), Fe 0.132 (1), Fe 0.486 (12)
4271.524	234	8.6	−3.43	+.049	1.548	Fe .170 (4), Fe .764 (7)
4289.946	270	9.7	+0.17	−.002	9.933	Cr 9.725 (5), Ti+ 0.230 (2), Fe 0.380 (1)
4307.824	45	8.1	−4.87	+.070	7.892	Ti+ .880 (8), Fe .906 (7)

λ	n	|Δ|	Δ		Recommended	Identification and Remarks
			km			
4325.761	249	10.6	+6.03	−.087	5.674*	Fe .765 main, but Sc+ 5.000 affects blend
4340.474	350	8.2	−0.64	+.009	0.466	Hγ
4351.841	233	9.0	−0.21	+.003	1.839	Cr Fe+ .762 (5), Mg .916 (5)
4374.931	174	10.4	+1.21	−.016	4.915*	Sc+ .46 (1), Y+ .96 (5) adjusted
4395.130	106	10.8	+4.96	−.073	5.044	Ti+
4404.723	86	7.7	−1.33	+.020	4.752	Fe .752
4415.136	37	7.1	−1.10	+.016	5.125	Fe .125, possibly blended with Sc+ .55
4481.238	361	8.4	−4.85	+.072	1.310*	Mg+ .13, Ti .26, Mg+ .33, latter component apparently strongest
4501.284	47	11.5	+1.45	−.022	1.270	Ti+ .270
4508.290	24	8.2	−0.67	+.010	8.290	Fe+ .290
4515.343	23	5.6	−1.90	+.029	5.340	Fe+ .340
4522.703	27	9.4	0.00	.000	2.701	Fe+ .633 (3), Ti .802 (2)
4533.972	107	10.1	−5.52	+.083	4.055*	Ti+ 3.97 main but Fe+ 4.17 contributes
4549.530	305	8.5	−1.67	+.025	9.550	Fe+ .48, Ti+ .62 assumed equal intensity
4571.986	34	8.2	−1.40	+.021	1.980	Ti+ .980
4583.848	45	12.1	+9.59	−.147	3.701*	Fe+ .841 main but Ti+ .45 contributes
4861.343	36	15.0	−4.12	+.067	1.326	Hβ

SUPPLEMENTARY LIST

λ	n	|Δ|	Δ		λ Recommended	Identification and Remarks
			km	λ		
3968.488	2	4.7	− 4.70	+.062	8.465	Ca+
4033.083	15	11.1	+11.13	−.150	2.933*	Fe 2.458, Fe 2.636, Mn 3.070, Fe 3.183
4132.083	29	10.7	− 6.39	+.088	2.141	V 1.952 (2), Fe 2.062 (10), −2.533 (3)
4246.844	49	11.1	− 7.01	+.099	6.943*	Sc+ 6.84, Fe 7.44
4282.682	13	13.4	+ 4.26	−.061	2.621*	Fe .41, Ti .70
4300.056	11	15.4	+ 9.81	−.141	9.885	Ti 9.640 (2), Ti+ 0.048 (3)
4315.022	18	19.1	+16.40	−.236	4.786*	Sc+ 4.09, Ti 4.32, Ti .81, Ti+ .98, Fe 5.10
4416.962	11	13.2	+ 0.03	.000	6.937	Fe+ 6.822 (3), Ti 7.282 (1)
4443.817	13	18.8	+16.46	−.244	3.578	Fe .196 (3), Ti+ .807 (5)
4468.502	16	11.6	− 9.48	+.141	8.643*	Ti+ 8.495 main, but Ti+ 9.149 contributes
4528.631	6	11.8	−10.35	+.156	8.619	Fe .619, possibly components to red
4563.769	9	6.8	+ 2.43	−.037	3.767	Ti+ .767

NEWS AND COMMENTS

Dr. Robert G. Aitken, director of the Lick Observatory, has gone to England where he will receive the medal of the Royal Astronomical Society.

General Ferrié, Chairman of the International Joint Commission on Longtitude, died on February 16th.

M. Guillaume Bigourdan, formerly director of the Bureau International de l'Heure, Paris, died at the age of eighty years.

Dr. Louis A. Bauer, formerly director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, died on April 12th at the age of sixty-seven years.

Mr. Ernest A. Hodgson, M.A., seismologist of the Dominion Observatory, Ottawa, who while on leave of absence for two years has been carrying on research at the St. Louis University, Miss., has been awarded the Ph.D. degree by that institution. The subject of Mr. Hodgson's dissertation was "A seismometric study of the Tango earthquake in Japan, March 7, 1927."

Mr. P. M. Millman who graduated at the University of Toronto in 1929 and obtained the R.A.S.C. gold medal, and who has been a graduate student at the Harvard Observatory since then, has been given the Ph.D. degree by Harvard University. During the past year the Carnegie corporation of New York undertook to supply the funds for ten fellowships, each of value $1,500, to be administered by the Royal Society of Canada, and to Mr. Millman one of these has been awarded. He will devote himself to research on meteors, working at the Harvard Observatory.

Mr. W. S. Armstrong, research assistant in the Department of Astronomy in the University of Toronto during the session 1931-1932, was given the M.A. degree on June 10th. Mr. Armstrong made a research into a tube photometer and an account of his work was presented at the May meeting of the Royal Society of Canada in Ottawa.

REDeL.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

The David Dunlap Observatory

This great project is going forward steadily. The 74-inch reflector was ordered in May, 1930, and its mounting is well advanced towards completion. The contract for the 61-foot dome to cover it was given in November, 1931, and rapid progress is being made on it. Tenders for the erection of the Administration Building have been invited by advertisement in the press and construction will proceed actively during the summer.

A Twelve-inch Steel Mirror

Mr. H. C. B. Forsyth, of Vancouver, reports the completion of a 12-inch stainless steel mirror which he says performs well. With a power of 367 (the highest available) the stellar images were excellent. The final figuring was done by testing on Polaris. The tube is a wooden box of square section. Mr. Forsyth's conclusion is, "From the result of this first effort with the steel, I am satisfied that I would not spend time again on a glass speculum as, from the experience I have had, I feel confident I could produce others with less actual labour than is entailed with glass, and the elimination of the silvering is a great relief."

Periodicities in Solar Phenomena

All agree that the study of the sun is of extreme importance since all life and development on the earth are dependent upon its radiation. Consequently observations of solar phenomena are continually being made by astronomers in many countries. Analyses of some of these observations were presented recently in two papers to the National Academy of Sciences, and a synopsis of the results obtained as printed in *Science* is given herewith.

Periodicities in solar variation: C. G. Abbot. Summary was made of the observations of the Smithsonian Astrophysical Observatory since 1895, including references to various instruments for scientific work. Among them is the periodometer which has been employed to discover and evaluate periodicities in solar variation and in the temperatures of Clanton, Alabama,

Washington, D.C., and Williston, North Dakota. The variation of the sun since 1918 is well represented as the sum of 7 periodicities, respectively of 7, 8, 11, 21, 25, 45 and 68 months. The temperature departures of the 3 stations named are also closely represented as the sum of these periodicities supplemented by two or three others which seem to be of terrestrial rather than of solar origin. However, at each station the sum of the amplitudes of the of the amplitudes of the terrestrial periodicities. This indicates that temperature departures are largely governed by variations of the sun, and holds out a hope of long period forecasts possibly extending for several years in advance. Further investigation must ensue before this hope can be thoroughly tested.

The nature of the solar cycle: W. S. Adams and S. B. Nicholson. The physical appearance of the sun varies from day to day as the sunspots, faculae and prominences develop and disappear on its surface. These phenomena may be distributed irregularly around the sun so that the number of objects visible at any time depends on the rotation period of the sun which approximates to a month. Their average monthly frequency, therefore, is an indication of the actual solar activity. The solar activity measured by this method fluctuates irregularly in cycles ranging from six to fifteen months and shows variations up to one fourth its mean value. The solar cycle which is most nearly periodic and which has the largest amplitude is of about eleven years' duration. This period may vary between nine and fourteen years and the amplitude of the cycle by about 50 per cent. of its average value. Period and amplitude are apparently unrelated. It seems probable that both the quantity and quality of solar radiation vary during this cycle and many attempts have been made to correlate terrestrial phenomena with sun-spots. Definite correlations have been found with the variations of terrestrial magnetism and its related phenomena. There is evidence of a slight correlation between sun-spots and atmospheric temperature in certain regions on the earth and with other factors of weather and climate for limited regions and for limited time intervals. These correlations are so uncertain that, in the majority of cases at least, predictions based on them have very little weight.

The Einsteinian Bending of Light Rays

Attempts to test Einstein's prediction that light is deflected in passing through the sun's gravitational field have been made by utilizing photographs taken at the total solar eclipses of 1919, 1922 and 1929. At the 1929 (May 9) eclipse three observers, Freundlich, von Klüber and von Brunn, of the Astrophysical Observatory at Potsdam, obtained four photographs at Takengon in Sumatra, each containing 17 to 18 star images. These when measured by them gave a deflection of 2″.24 for a ray grazing the sun's limb. Einstein's predicted value is 1″.75 and this value had

been verified approximately by the previous expeditions. The three German astronomers then examined the Lick results of 1922, and by a different reduction of the measurements obtained the value 2″.2 instead of 1″.75. Thus according to these observers there is a deflection, but 30 per cent greater than the predicted value.

Now which is correct? To obtain suitable photographs is a very difficult and delicate task, and to measure the minute displacements of the star images and interpret them is an equally difficult problem. In *Science* for May 20, 1932, the matter of measurement and reduction is ably discussed by Dr. Robert J. Trumpler who assisted in taking the Lick plates in 1922 and who was responsible for their measurement. He takes objection to the method used in reducing the Potsdam plates and contends that the correct value from them is 1″.75, in agreement with previous observers.

C. A. C.

MEETINGS OF THE SOCIETY

AT HAMILTON

February 8.—The meeting was held in the lecture hall of the Public Library, at 8.15 p.m.

The President gave a few remarks in reference to sending an eclipse party to Quebec. Mr. J. A. Marsh gave a vivid description of the 1925 eclipse. He urged all those who could, to avail themselves of the opportunity of seeing the coming spectacle.

Mr. J. A. Little introduced the speaker of the evening, Professor Wm. Findlay, of McMaster University, who chose for his subject "The Motions of the Moon". It was shown that the motions of the moon are quite complicated. The path of the moon follows more or less closely the ecliptic and frequently crosses it. This explains why eclipses occur. The lecturer explained why some are seen only in northern and some in southern hemispheres, and why the length of time varies with different eclipses. Dr. Findlay told us that the man in the moon always faces the earth and 41 per cent. of the moon's surface has never been seen.

March 8.—The meeting was held in the usual place at 8.15 p.m.

The President, Mr. W. S. Mallory, made a few remarks in reference to raising the necessary amount of money to finance an eclipse party next August. He stated that one third of the amount of money required is already subscribed.

Owing to the illness of Professor H. R. Kingston of London, Dr. Wm. Findlay of McMaster University was the speaker of the evening. His subject was "Einstein's Theory of Relativity". The subject was very skilfully handled, tracing the history of these ideas from early Greek thought to Einstein's modern theories. The theory teaches that mass varies with velocity and that mass and energy are the same thing in different forms. Professor Findlay mentioned that the difference between Einstein's theory and Newton's, was so slight as not to effect the ordinary person in his day-to-day life. Many questions were answered by Professor Findlay in an interesting manner.

April 12, 1932—The regular monthly meeting was held in the Public Library hall at 8.15 p.m. The President was in the chair.

Dr. Wm. Findlay of McMaster University introduced the speaker of the evening, Professor H. R. Kingston of the University of Western Ontario. His subject was, "The Total Eclipse of the Sun next August."

The lecture was illustrated with a large number of slides. The lecturer traced the history of eclipses through the past, noting that they were frequently associated with important events, the ancients regarding them as ill omens. Some of the difficulties of calculating the time and place of eclipses were pointed out. These were chiefly due to the variations of the moon's path. The oldest eclipse on record, we were told, occurred over

2000 years B.C. in China, while the first one of which we have accurate calculation was in 911 B.C.

Professor Kingston fully explained how and when they may occur. The maximum number of both the moon and sun together being seven in one year. 1935 will be such a year, having four of the sun and three of the moon. He stated that the extreme width of the path of totality is 170 miles; the one this year being approximately 100 miles wide, the western edge being at Montreal and stretching eastward.

The speaker gave a very vivid description of an eclipse expedition, of which he was a member, to Green River, Wyoming, U.S.A., in 1918, and also of their keen disappointment due to clouds in London in 1925.

AT TORONTO

March 8.—The meeting was held at 8.00 p.m. in the McLennan Laboratory (formerly Physics Building), University of Toronto; R. A. Gray in the chair.

V. W. G. Wilson, 1396 King Street West, Toronto, was duly elected to membership in the Society.

Astronomical phenomena for the ensuing two weeks were outlined by Frederic L. Troyer.

J. R. Collins reported that the committee in charge of preparations for observing the eclipse of August 31 had two expeditions under consideration, one to observe from the north side of the St. Lawrence river, and the other from the area south of the river. There is also under consideration a project that members of the society may explain about the eclipse to the residents of the various municipalities in the path of the eclipse.

Mr. Collins also reported receipt of a telegram from Harvard College Observatory announcing discovery of Grigg's Comet near the great nebula in Orion. This comet, of magnitude 16, was observed March 7 at Mount Wilson observatory.

W. S. Armstrong, B.A., research assistant in astronomy, University of Toronto, then addressed the audience on "The History and Development of Our Calendar". Mr. Armstrong described the various lunar and solar cycles used in making the calendars of many ancient civilizations: the lunar calendar of the Babylonians and its development into the modern Jewish calendar, the solar calendar of the Egyptians and its effect on the later calendars of Greece and Rome. Indicating the necessity of intercalary months in the ancient lunar calendars, and intercalary days in those based on the sun or the tropical year, he traced the development of these periods of intercalation to our present Leap Day. He also pointed out the reasons for and the results of the reforms of Julius Caesar and Pope Gregory XIII, and discussed the many complicated tables and cycles which have been used in the finding of the correct date for Easter Sunday, which was based entirely on a lunar calendar until the present rule, "first Sunday after the first full moon after the vernal equinox," was adopted a few generations ago.

FRED L. TROYER,
Acting Recorder

April 12, 1932—The meeting was held in the usual place, at 8 p.m. Mr. R. A. Gray in the chair.

There were two elections to membership: Gustavus W. Cook, Wynnewood, Pennsylvania, U.S.A.; Clifford Rose, P.O. Box, 914, New Glasgow, N.S.

Mr. F. L. Troyer gave a very able description of the constellations Boötes, Coma Berenices and Canes Venatici.

The address on "An evening with Galileo" was given by Mr. David J. Howell. Even at an early age Galileo gave indication of the man he was to be, by his ability at play and his ingenuity at making toys and devising games. Later he had strong inclinations towards art and music, and became an authority on painting and a very skilful player on the lute. Sent to the University at Pisa to study medicine, he became absorbed in mathematics, and later was appointed professor of that subject at Pisa University, thence to Padua University, and then commenced the most interesting and productive years of Galileo's life. Here he invented the geometrical and military compass, also the thermometer. Here also, in 1609, he produced his first telescope. With his second instrument he began his astronomical investigations, and startled the world by his discovery of the four moons of Jupiter. It was at Padua that Galileo spent the happiest hours of his life, an early compensation for the troublous period to come. In his pleasant garden gathered his friends and pupils discussing divine philosophy, a little music—so sped the happy hours. From Padua he went to Florence to become mathematician and philosopher to the Grand Duke of Tuscany, where he discovered Saturn's rings, the phases of Venus and the spots on the sun.

Galileo's work on the Ptolemaic and Copernican systems was concluded in 1630, and published two years later, the plague intervening, but surely no other book and its author were submitted to such trials and tribulations, before the necessary permission for publication was granted. The work was received almost everywhere with enthusiasm, but it aroused the enemies of Galileo, with the result that a few months later the order came from Rome to sequester every unsold copy, and to suspend publication. Galileo was forced to journey to Rome to face the Inquisition in spite of his age and serious ill-health, he was vehemently accused of heresy, imprisoned and forced to recant his teachings. He was subsequently released, and allowed to return to his villa at Arcetri. In 1637, just before his sight failed him, Galileo made his last discovery, namely, the moon's libration. He died on January 8, 1642.

Mr. H. P. Mills then gave a delightful account of his visit to Galileo's villa at Arcetri, illustrated with cinematograph pictures (taken by himself) of Naples, Capri, Rome, Florence and the villa. Galileo's beautiful house and garden were shown in fine detail, a very fitting conclusion to the preceding lecture.

Dr. C. A. Chant expressed the thanks of the audience for the lecturers'

extremely interesting addresses, and their generous donation to the Society of the slides shown.

April 28, 1932—The meeting was held in the usual place at 8 p.m. Mr. R. A. Gray in the chair. There were two elections to membership: Charles Svoboda, Maple Heights, Bedford, Ohio, U.S.A.; Leon Cap, M.B.A.A., 222 Rua Vergueiro, Sao Paulo, Brazil.

Professor R. K. Young gave an address on "Expeditions to Quebec to observe the Total Eclipse of the Sun on August 31st, 1932." The phenomena of the eclipse of the sun differs in its appeal according to the observer. To the average amateur it is a spectacle of unusual interest, but it contains for the scientist a fund of information and an opportunity which occurs too seldom—a few precious moments if the sky is clear, but if cloudy, a sense of keen disappointment, with many months of preparation and resultant expense utterly wasted. The various scientific expeditions will be concerned mainly with efforts to secure an accurate timing of the moment of the eclipse, photography of the various phenomena, such as the corona and the star field around the sun. Other phenomena, such as the direction and velocity of the wind, possible change in the barometric pressure, fall in temperature, direction and velocity of the shadow bands, width of the shadow belt and position of its boundaries on the earth, accurate timing of the moment of the eclipse and reappearance of the sun as observed from various points across the shadow belt, cloud effects and changes, if any, could be determined by the amateur, thus supplying much valuable information to the scientist for later compilation.

Professor Young's address was directed towards those amateurs who would be interested in securing this information, and instructions were given for locating at various points of vantage across the path of the shadow as differing from those occupied by the various scientific expeditions, the accurate setting of timepieces, or determination of their amount of error, and methods of observation of the various phenomena. The lecturer enumerated a list of questions as compiled by Professor E. W. Brown, regarding these observations. The questions provided for answers regarding the timing of the phenomena and the position of the observer. If every amateur expedition, preferably scattered across the shadow belt, were provided with such a list of questions, their findings, if accompanied with any degree of accuracy, would undoubtedly prove to be of great assistance to the professional expeditions, which must, of necessity, owing to the short duration of totality, confine their activities to the central portion of the shadow belt.

S. C. Brown, *Recorder.*

AT WINNIPEG

December 9, 1931—The regular meeting was held in Theatre "A", University Building, at 8.15 p.m. The speaker of the evening was the President, Dr. Neil John Maclean.

Dr. Maclean chose as the subject of his address, "The Evolution of the Telescope." Placing the age of telescopic astronomy at 300 years, Dr.

Maclean said that credit for the invention of the first telescope must be given to Lippershey, a native of Flanders, who constructed a telescope in the year 1608. Two years later, in 1610, Galileo constructed a much improved instrument by means of which he was able to see Jupiter and four of the satellites. These were the first heavenly bodies to be discovered by means of a telescope.

Comparing the power of modern instruments, Dr. Maclean said that the diameter of Galileo's telescope was 2¼ inches, while that of the largest telescope in the world, the Hooker telescope at Mount Wilson, California, was 100 inches and admitted 2500 times as much light as Galileo's instrument.

Dr. Maclean outlined some of the work in which astronomers are engaged at Greenwich, England, at Ottawa, at Victoria, at Mount Wilson, Cal., all of which observatories he had visited. The lecture was illustrated throughout by a fine series of slides. At the conclusion the Vice-President, Mr. A. W. Megget, after conveying to Dr. Maclean the thanks of the audience, threw the meeting open for questions. Discussion followed in which many members participated.

January 13, 1932—The regular monthly meeting of the Winnipeg Centre was held in the usual place at 8.15 p.m. The President, Dr. N. J. Maclean, was in the chair.

The following were elected to membership: Dr. Rudolph Michaud, 14 Monterey Apts., 45 Carlton St., Winnipeg; Mr. Grant Mulheron, 309 Ash Street, Winnipeg.

The speaker of the evening was Professor V. W. Jackson of Manitoba Agricultural College. The subject of the address was "Limits of Life."

This very title "Limits of Life," said Professor Jackson, reveals a great misconception, for life is almost synonymous with limits. Life is the most limited thing in the universe, and if the atmospheric temperature exceeded 25 degrees from the usual maximum or minimum temperatures, all life would perish. Five miles up or five miles down all life ceases. Life exists within narrow limits of temperature, pressure, light, water and protoplasm, oxygen, isoelectric stability, limited in size, age and space.

TEMPERATURE: Protoplasm the physical basis of life is limited in temperature from zero to 50°C., which is only 1/1,000,000 the temperature of the parent sun, and when we consider cosmic temperatures of 32 million we realize that 50° is a small range, and life that we know must be very limited in space.

PRESSURE: Five miles up or five miles down seems the extreme limit of life. Glaisher in a balloon ascent, in 1862 became unconscious at 29,000 feet. Tissandier, in 1875 became unconscious at 26,500 feet. Mallory and Irvine, in 1924 in their epic ascent of Mount Everest were so exhausted at 26,800 feet that a step every three minutes meant fatigue. Somerville and Norton, likewise became exhausted at 28,200 feet. Greater heights than these have only been attained with artificial respiration by airplane or balloon

with no exertion. The flight of the condor is never beyond 23,000 feet. The limits below the water are even more striking. The naked diver, the pearl diver, cannot stay below the surface more than two minutes, nor at a greater depth than 30 feet; and in the diving bell 300 feet for 20 minutes. In building the St. Louis bridge, 14 out of 600 died at 4½ atmospheres pressure. This was known as "caisson disease." Dredging has not revealed any forms of life in the greatest depths and the highest peaks (over five miles) are devoid of life of any kind.

PHYSIOLOGICALLY: The life cell must be sustained by a homogeneous solution, that is, it must be isotonic, or it will be under stress and soon changed or alternated. Bog plants are in an isotonic solution of .11. Zerophitic plants of the desert .24. Alkaline plants around the slough are dwarfed and limited at .51. The osmotic pressure of the blood is and must be remarkably constant. The more complex, the more constant it must be—hence the protective regularity of the kidneys. A slight change in the osmotic pressure of chlorophyl will produce starvation and it is in this way that the cacti of the desert exist without leaves. Certain plant cells in the hypertonic solution cause concentration, and starch is formed as a result of this slight plasmolysis. Loeb stimulated the artificial parthenogenesis in sea urchin eggs by the slight addition of butyric acid to sea water and then in hypertonic sea water for a short time they developed into normal larvae. Blood pressure is the component of the heart beat and viscocity, 6 or 7% carbon dioxide causes hydration, hence greater viscocity of the venous blood and the necessity of an oxidation protoplasm requiring 80 to 90% water for its activity. Hysterosis or heredity of gels simulates life. A 10% gel dried to 97% will return to 10% gel on rehydration, whereas the 30% gel dried to 97% will return to 30% again and on to the third and fourth generation. The inbibition of seeds illustrates the relation of water to protoplasm.

The isoelectric point of red blood cells is 6.7 approximately, (the neutral point). Blood serum is ampholytic, fibrinogen 4.8, egg albumen 4.7, but blood must be isoelectric or ampholytic at about 6.7 and a serum and protoplasm for buffer solutions to prevent sudden change. At 8% sugar in the blood causes diabetes.

LIGHT. Although light is our source of energy from the sun and essential to life; yet within limits the blond race being heliopholic migrates northward; only the brunette or heliophile can thrive under the tropical sun. Birds treated to ultra-violet rays in their fall migration turn north again. Corn and many crops thrive better in regulated light or partial daylight, hence the short growing season of the north is more successful than tropical sun. Tobacco is often grown under scrim or cloth to regulate the light. The house plant does not grow to the light; it is forced to the light by the greater growth on the darker side.

SIZE. Professor Oliver has recently published a book on the size of plants in which he shows that the size is limited to physical conditions; and

the dinosaurs seem to indicate that animal life is likewise limited to physical conditions.

AGE. Life's little while seems dwarfed to insignificance when compared with the life of other things. The life of radium has given us an approximation of two billion years as the radio-active existence of the earth. Dr. Arthur Compton, a great authority on the atom, says that with every breath everyone inhales atoms that Cæsar breathed, being wafted around the world, washed in tropical rains but still breathed by every living creature. If all the two billion people of the world counted as fast as they could it would take ten thousand years to count the molecules in a drop of water (2×10^{21}).

I sometimes think that never blooms so red the rose
As where some buried Cæsar bled;
And every hyacinth the garden holds dropped in its lap
From some once lovely head.

Sir James Jeans in his "Mysterious Universe" suggests that the mystery of life is its insignificance—a by-product of the main line of the universe, the physical conditions under which life is possible is only a tiny fraction of the range of prevailing physical conditions. Life is limited to an inconceivably small corner of the universe, limited to the planets, and only one in 100,000 suns could possibly have these and of our planets only one seems favourable to life. Recent investigation with the largest telescope and better photographic plates does not reveal the supposed artificial canals on Mars or seasonal changes that could not be explained on a purely physical basis, and it is now known that the oxygen of its atmosphere is only 15 per cent of that of the earth; and on the planet Venus only 1/10 of 1 per cent, making it difficult to conceive of the possibility of life thereon in any way comparable to life we know.

Time brings changes and adaptations, but since a planet owes its birth to the conjunction of two stars passing within three diameters of one another, even in a billion years there would be only one chance in 100,000 of a sun surrounded by planets, and in the only planets known only 1 in 9 are favourable to life. Primeval matter must go on transforming itself into radiation for millions and millions of years to produce a minute quantity of inert ash on which life can exist and then by an almost incredible accident and nothing else, must be thrown out of the sun which has produced it and condensed into a planet and to cool until such a residue is just suitable in temperature, pressure, oxygen and other physical conditions to which life is limited. It is even surprising that oxygen figures so largely in the earth's atmosphere in view of its readiness to enter into chemical compound with other substances; itself, the accumulated produce of vegetation; but if so the vegetation would be a measure of oxygen and since there is only a trivial amount on our nearest neighbours Venus and Mars, this would suggest a scarcity or absence of life.

Is Life an accident in the extravagant preparation of the universe, which may have some more stupendous end in view, or, thrusting humility aside, shall we venture to imagine that it is the only reality which creates instead of being created, the colossal masses of stars and nebulae; which young and more vigorous matter would at once destroy, the life it had created?

S. C. NORRIS, *Secretary.*

AT VICTORIA

April 22, 1932—A regular meeting was held on this date. President P. H. Hughes was in the chair and about 65 members and friends present. Mr. James Duff gave an interesting talk on the constellation Leo. Following this, the president announced that the Council had been in communication with the General Council of the Society regarding a proposal for increasing the usefulness of the Society, especially for young people. He then read the following resolution.

Resolved: To afford greater opportunity for young people to develop an interest in and knowledge of astronomy, the Victoria Centre of the Royal Astronomical Society of Canada hereby institutes, subject to the following conditions and regulations, a class of members to be known as Junior Members.

1. Junior membership shall be open to all persons under 21 years of age.

2. Junior members must be duly elected to membership as full members of the Society.

3. The annual dues of Junior members shall be One Dollar per year payable upon election and thereafter in advance in January of each year.

4. Annual dues of Junior members shall include:—
   (a) Use of the Library of the Victoria Centre.
   (b) Subscription to the JOURNAL of the Society.
   (c) Admission to all regular and observational meetings of the Centre and to such other activities as the Centre may from time to time arrange.

5. Junior members shall not have the right to vote upon any questions that may come before the Centre for such disposal.

6. The Council of the Centre may make such changes in these regulations as it may from time to time deem beneficial in promoting the intent of this resolution.

Following the President's remarks, passage of the resolution was proposed by Mr. W. T. Bridge and seconded by Mr. F. Napier Denison and was carried unanimously amid applause.

The president then announced the following committee to draw up a programme for the summer.

J. A. Pearce, Ph.D., F.R.S.C., Chairman.

F. S. Hogg, M.A., Ph.D.

Charles Hartley.
H. Boyd Brydon.

Upon request by the president, Dr. Pearce outlined the tentative summer programme as follows:—

There will be conducted during the summer months a course in astronomy designed to give the members training in the fundamentals of practical astronomy. The subjects taught will include:—

The celestial sphere; Constellation study; Determination of time; Determination of latitude; Study of lunar features; Drawings of sun-spots; Making of sun-dials; Occultations of stars; Observations of planets, double stars, clusters, etc.

The course will be open to all members of the Society. Meetings will be held weekly during July, August and September.

The following were elected members of the Society:—

Horace West, Esq., Victoria, B.C.
Miss Anne Rathbone, Gibson's Landing, B.C.
Arnold Redmayne, Victoria, B.C.

The following were elected Junior members:—

Miss Barbara Cox, Victoria, B.C.
Mr. Peter Cox, Victoria, B.C.
Mr. M. D. Jamieson, Victoria, B.C.

Announcing the speaker of the evening the president said Mr. F. Napier Denison, our first president, needed no introduction. Mr. Denison then gave a most interesting lecture, well illustrated by lantern slides, on "Seismological Observations and Slow Earth Movements."

H. Boyd Brydon, *Secretary.*

The Royal Astronomical Society of Canada

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A GENERAL INDEX

to Volumes 1-25 of the Journal of the Royal Astronomical Society of Canada and to its previous publications (dating from 1890) will be published about July 1, 1932.

The Index has been prepared by W. E. Harper, M.A., Assistant Director of the Dominion Astrophysical Observatory, Victoria, B.C. Subjects and names are arranged in a single alphabetical list, with numerous cross references.

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